CMS Detector & Commissioning Status
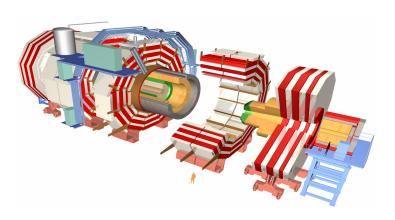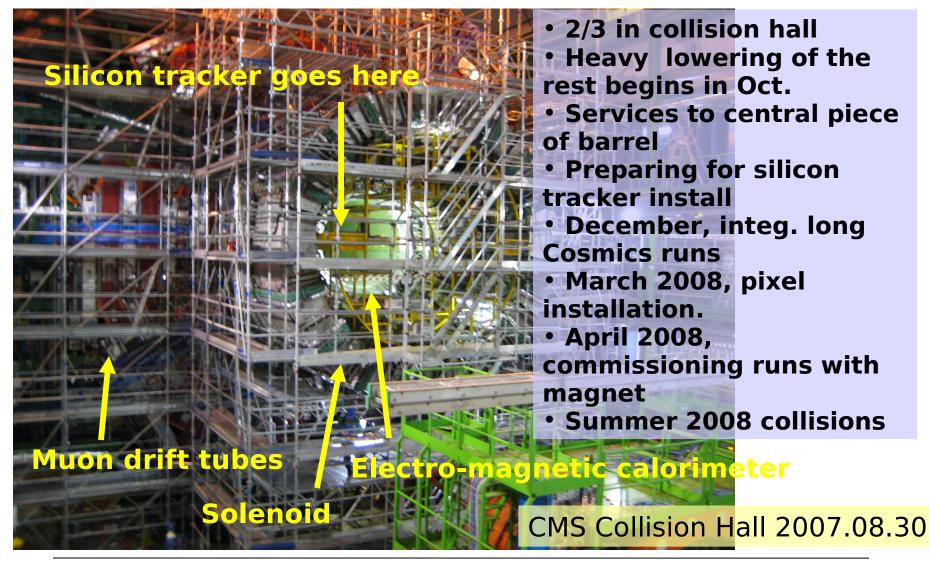

DOE Annual Program Review

September 26, 2007

Kaori Maeshima

CMS Collision Hall – Busy & Crowded

Silicon tracker goes here

Muon drift tubes

Solenoid

Electro-magnetic calorimeter

CMS Collision Hall 2007.08.30

- 2/3 in collision hall
- Heavy lowering of the rest begins in Oct.
- Services to central piece of barrel
- Preparing for silicon tracker install
- December, integ. long Cosmics runs
- March 2008, pixel installation.
- April 2008, commissioning runs with magnet
- Summer 2008 collisions

New Phase: *Integration/commissioning*

Status Overall:

During the past year, much of detector components are lowered & placed at UX5. They are being integrated & commissioned to be read out as *ONE experiment*, while the detailed work to fully understand each sub-detector continues.
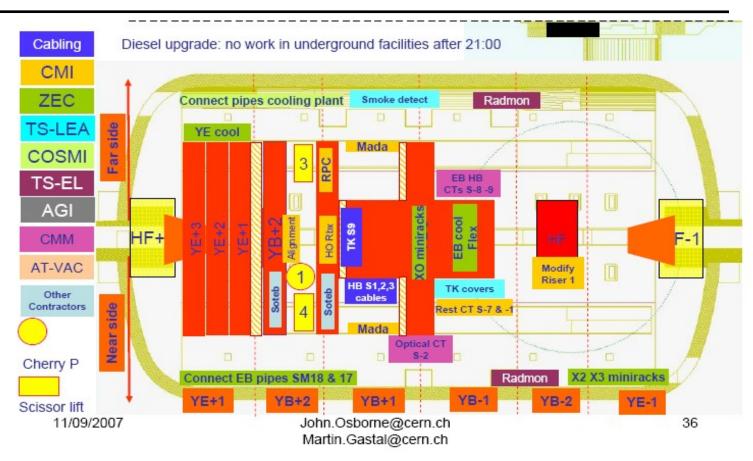
Outline of this talk:

- **sub-detector status (brief)**

- **integration and commissioning theme:** *Towards Remote Operation (ROC) at FNAL.*

  – **Strong FNAL contribution, working together with USCMS & international CMS for *the CMS operation.* At this point, much fundamental work are the same for local & remote operation.**

  – **LHC@FNAL-- the new location for the FNAL ROC operation**

Lowering of Endcap muon and Endcap calorimeters down to UXC55 (100m down)

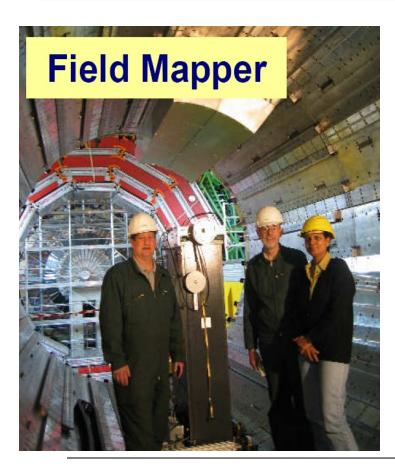# Current Situation at UX5 (Sept. 17th)

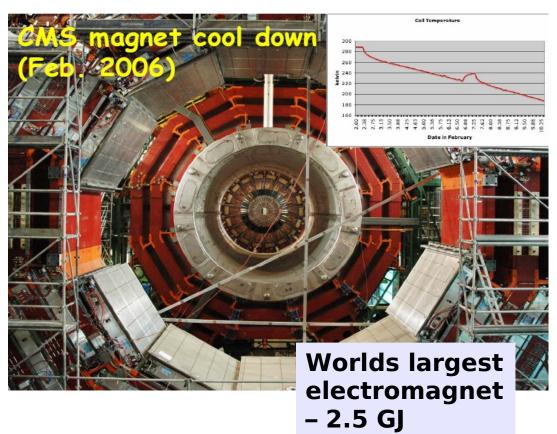- **Installation is fully underway**
    - **Whole positive side and solenoid and central yoke block are in the Collision Hall**
    - **The remaining muon detectors are upstairs, complete, and ready for lowering**
    - **HB and EB are installed in the Solenoid**

CMS Magnet Status

Cooled down. Inserted HCAL late March 2006. Field mapped by FNAL physicists during July - October 2006 MTCC-I $ II (_Magnet Test Cosmic Challenge_) (more on MTCC, later)
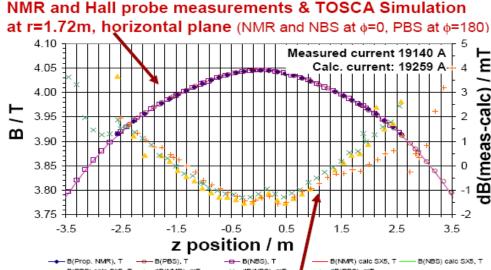

Field Mapper

CMS magnet cool down (Feb. 2006)

Worlds largest electromagnet – 2.5 GJ

Magnetic Field Mapping

NMR and Hall probe measurements & TOSCA Simulation at r=1.72m, horizontal plane (NMR and NBS at φ=0, PBS at φ=180)

Measured current 19140 A
Calc. current: 19259 A

B(Prop. NMR), T — B(PBS), T — B(NBS), T — B(NMR) calc SX5, T — B(NBS) calc SX5, T — B(PBS) calc SX5, T — dB(NMR), mT — dB(NBS), mT — dB(PBS), mT
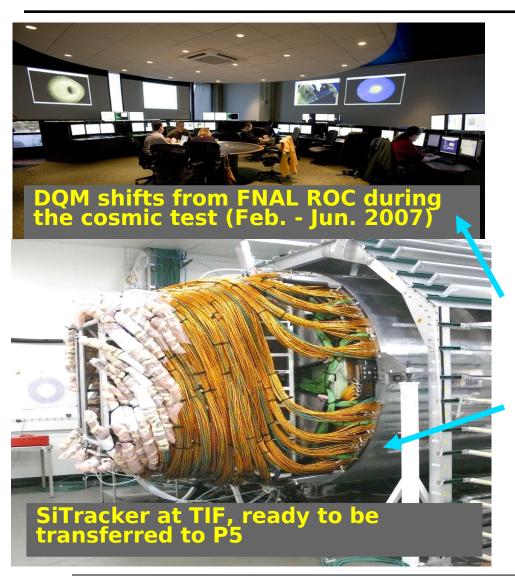
PBS: positive B sensor, NBS: negative B sensor

Very good agreement between measurement and simulation !

FNAL designed, built, and used the tools to "map" -- good to a few parts per 10,000

SiTracker: Tested & Ready to be Installed

DQM shifts from FNAL ROC during the cosmic test (Feb. - Jun. 2007)

SiTracker at TIF, ready to be transferred to P5

Completed commissioning at Tracker Integ. facility (TIF)

- . A large Si strip system (2Mch out of ~ 10Mch powered)
- operated at 15,10,-1, -10 and -15 ºC.
- 5M cosmics taken for noise, efficiency and alignment studies.
- Quality is excellent (few per mille dead or noisy channels). Efficiency > 99%.
- *Systematic DQM shifts from FNAL ROC, using many of general monitoring tools ROC group provided (more later).*

Tracker is ready for installation

- planed to start end of Oct.
- waiting for YB0 service work to complete.
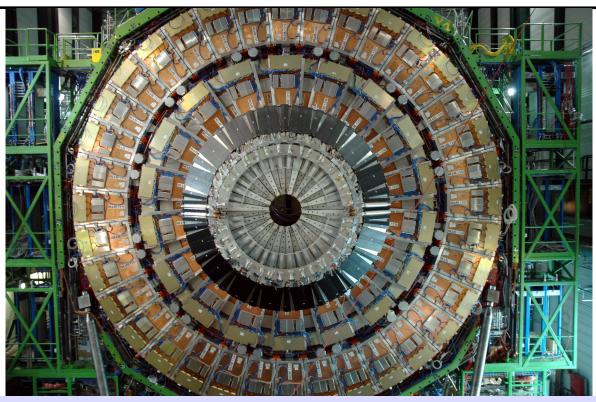- effort is led by FNAL scientist resident at CERN

HCAL

HF Lowering

HB Lowering

- **HF, HB, HE+, HO at UX5**
  - **Installation of cabling and services**
  - **commissioning and integration (trigger, DAQ, Calibration,.....)**
  - **HF+ was the first detector ready to be read out for the global commissioning run**
- **HPD noise study and lifetime tests**
- **beam tests of the combined HE/EE/ES sub-detectors (using FNAL ROC to monitor/analyse data)**
- **Preparations for SiPM beam tests as a study of replacement photo-detection equipment for HO HPDs.**
- **Work on DB (offline, online, DCS), Detector Control system (DCS) in progress**
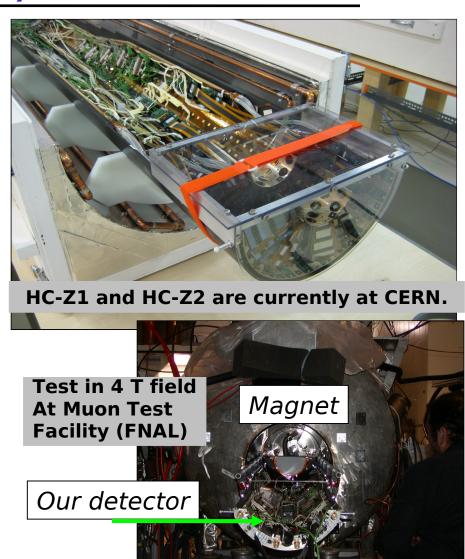
Final CSC Chambers (ME-1/3)

- Last (468th) CSC chamber installed on the ME-1/3 disks on March 8th, 2007 at 4:30 pm (CERN time)
- End of a chapter that started at FNAL with production of Chamber #1 on October 1998.
- 3 of 6 ME disks in position in UX5 (Collision Hall).
- commissioning and integration work in progress including trigger, DAQ, & DQM
- Hardware Laser CSC muon alignment work (large FNAL contribution) nearly completed

Forward Pixel Detector
(FNAL ⟶ CERN)

- **First TWO (of four) half-cylinders delivered to CERN in spring 2007.**
  - *Third half – just delivered to CERN last week*
  - *Projected completion of 4th half-cylinder is now late October/early November*
- **Test in 4 Tesla Magnetic field at FNAL successful**
- **Test of FPIX Pilot Run detector inside Tracker showed no significant increase in noise or change of signal of either FPIX or Tracker Inner Barrel**
- **PLAN TO PUT FPIX PILOT RUN DETECTOR IN MTCC WITH BARREL PIXEL PILOT RUN DETECTOR**
- **PLAN TO PUT FULL PIXEL DETECTOR INFOR 2008 RUN**
- **Commissioning done at CERN, however, the large part of monitoring operation are planned to be done from FNAL ROC.**

HC-Z1 and HC-Z2 are currently at CERN.

Test in 4 T field At Muon Test Facility (FNAL)

Magnet

Our detector

Why Remote Operation? Why FNAL?

- **Thousands of collaborators located all over the world**
- **Most of them not resident at CERN**
- **Collider H.E.P. facilities have, however, never been more concentrated at a single site**
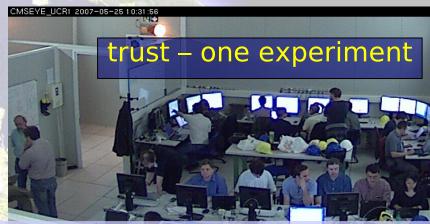- **Need to disperse and disseminate**

Advantage at FNAL:
- Natural base to serve large USCMS community
- LPC – LHC Physics Center
- Tier-1 center, Data Operation team
- Tevatron experiments' experience & resource sharing
- Remote work base for LHC accel. study & operation…
- Impact on future of HEP – way to operate --- ILC …….

Remote Operations

LHC @ FNAL Remote Operations Center

Infrastructure

Fermilab Remote Operations Center, LHC@FNAL

CMSEYE_UCR1 2007-05-25 10:31:56

trust – one experiment

CMS Underground Control Room 2007 MAY Global Integration Run. There are many of us (FNAL & USCMS people) in action here and there!

★ FNAL

★ CERN

technical ground

- Tools needed for remote status display
- Must be easy to use, flexible, drillable
- Coöperative with firewall, security
- Must survive trans-Atlantic crossing

3-fold approach to ROC

- **Infrastructure**
  - **LHC@FNAL – being used since Feb. 2007**
    - **CMS, LHC, & Outreach**
  - **WH11 ROC room – completed in the end of 2005. being used MTCC-I, II 2006, HCAL test beam and other tool development activities, and now as muti-purpose room (meetings, discussions, software/hardware development, etc.).**
- **Activities**
  - **MTCC I, II (Aug-Oct. 2006)**
  - **HCAL test beam (summer 2006, 2007)**
  - **SiTracker test (Feb. - Jun. 2007)**
  - **T0 shifts, Data Operation (Feb. 2007 -)**
  - **Global Runs End of Month (GREM, GREJ, GREJ', GREA, GRES..... 2007)**
- **Monitoring Tool Development**
  - **DQM (data quality monitoring) development (Trigger, HCal)**
  - **Web Based Monitoring Tool (WBM)**

Focus

- **Obvious:**
  - Effective Remote CMS online data quality monitoring is <u>not possible</u> without having a good CMS online monitoring system itself.

- **Therefore:**
  - Main focus of our (ROC group) effort has been to develop useful monitoring tools (location independent) with close coordination with colleagues at CERN, then, to implement/execute in the real environment via activities like: MTCC, SiTracker test, Global runs, cosmic runs, etc....
  - Enabling remote access of monitoring information outside of P5 requires additional layer of sophistication in design/implementation. The CMS experiment recognizes the importance of remote access and it is an integral part of <u>*conceptual design*</u> in much of area, however, it requires <u>development/*implementation work*</u> in large part and the ROC group based at FNAL is taking the leading role in the CMS experiment.

From "Feedback from MTCC" document
by Austin Ball (MTCC run coordinator)

*Ultimately the diligent work of hundreds of people over many years (aided by a little good fortune) transformed the "cosmic challenge" into a "cosmic success" for the CMS collaboration. Around 25 million "good" events were recorded with at least DT triggers and ECAL + TK in readout, of which 15M were at a stable field equal or greater than 3.8T. Data-taking efficiency reached over 90% for extended periods. Data transfer to some Tier 1 centers, online event display, **quasi-online analysis on Meyrin site, and fast offline data-checking at Fermilab** were some highlights of MTCC phase I which offered a first hand taste of a CMS-line running experience.*

FNAL ROC and MTCC

Coordinated effort with CERN MTCC Operation/Computing/Software groups.

MTCC-Phase 1 (August 2006)

Goal and Strategy (DQM was not running consistently at Point 5):
- transfer events to FNAL using T0/T1 facility
- locally run available DQM programs and event display systematically
- make results easily accessible to everyone as fast as possible (use WBM tool)
- Take shifts to contribute to the MTCC operation by doing quasi-online monitoring.

MTCC-Phase 2 (October 2006)

Goal and Strategy (DQM programs are running more systematically at Point 5):
- Do real time Data Quality Monitoring by looking at DQM results running at Point 5 and take official DQM shifts.
- Run Event Display locally on events transferred in real time.
- Continue to do quasi-online monitoring as in Phase-1 with the transferred data. This has the advantage of running on every event, and it is possible to do reprocessing with improved programs with good constants.

We have achieved both the phase 1 & 2 goals!

CMS MTCC at FNAL ROC

August 2006,
phase-1 MTCC at FNAL ROC.
Getting ready to look at Events

Oct. 31 Evening at FNAL
Nov. 1 Owl at CERN
Taking MTCC-II DQM shift

Histograms being examined
and Event Display shown
are in 'Real Time'!!!

http://uscms.org/roc
FNAL ROC page – Many Useful Links, kept up-to-date

September 26th, 2007   CMS Detector and Commissioning Status   18

- These are tools developed mainly by FNAL physicists over the years of CDF running/monitoring. These tools have been found extremely useful (especially by the Trigger/DAQ/subdetector experts at remote locations).

- In February 2006, we proposed to install the WBM tools to CMS. Shortly after we began the development and implementation.

- WBM is a general tool, and specific applications are rapidly increasing.

- In addition to the WBM software tool development, we also installed powerful server machines (cmsmon and cmsmon_dev) in order to distribute information outside of the experimental hall (P5) reliably.
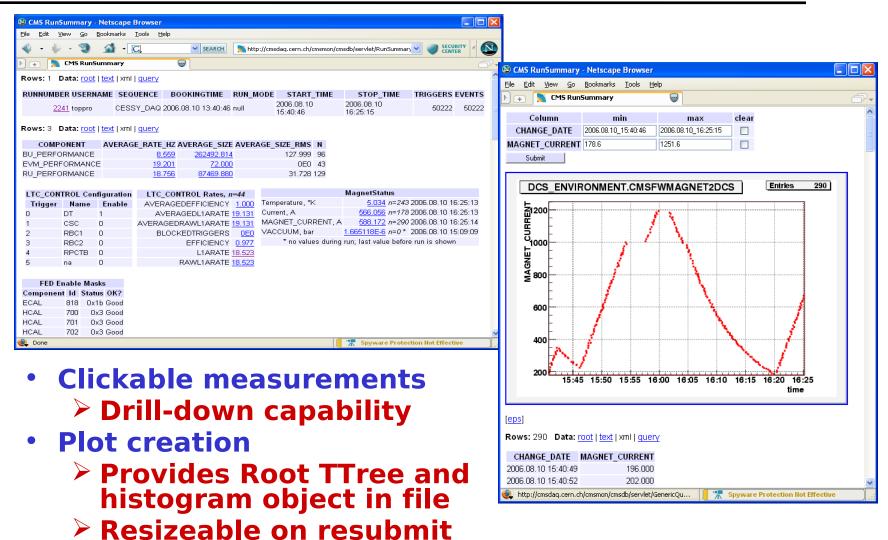
Web-based Monitoring

- **Wealth of information in database**
  - Trigger rates, event rates, cross sections, beam conditions, temperatures, voltages, environmental conditions, etc. …
  - Database is preferred locale for configuration and monitoring data persistency
  - Oracle 10 located at CMS site; replicated to offline world
  - Has current and historical status data
    - ✓ Latency ~ < 1 second to ~1 minute
    - ✓ Behind firewall for security reasons
- **Need a portal to gain access**
  - Provide display of contents
  - And provide access control
- **Typical data present, "Value vs. Time"**
  - Needs tools to access, plot, download, correlate
- **Complex, heterogeneous database**
  - Many schemas, many designers
  - Already have 140 schemas just in the online database & not nearly done
- **Central description needed**
  - Correlate across subsystems
  - Typical monitoring is "Value vs. Time"
    - ✓ *Global* meta-data descriptive tables

RunSummary Pages

- **Clickable measurements**
  - ➢ **Drill-down capability**
- **Plot creation**
  - ➢ **Provides Root TTree and histogram object in file**
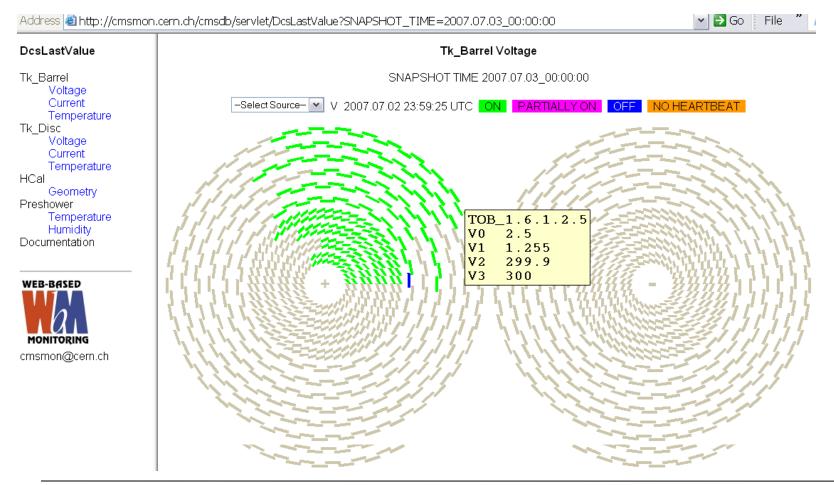 - ➢ **Resizeable on resubmit**

Environmental - Slow Control

- Access to current "right-now" conditions
- ...and historical settings and trends...
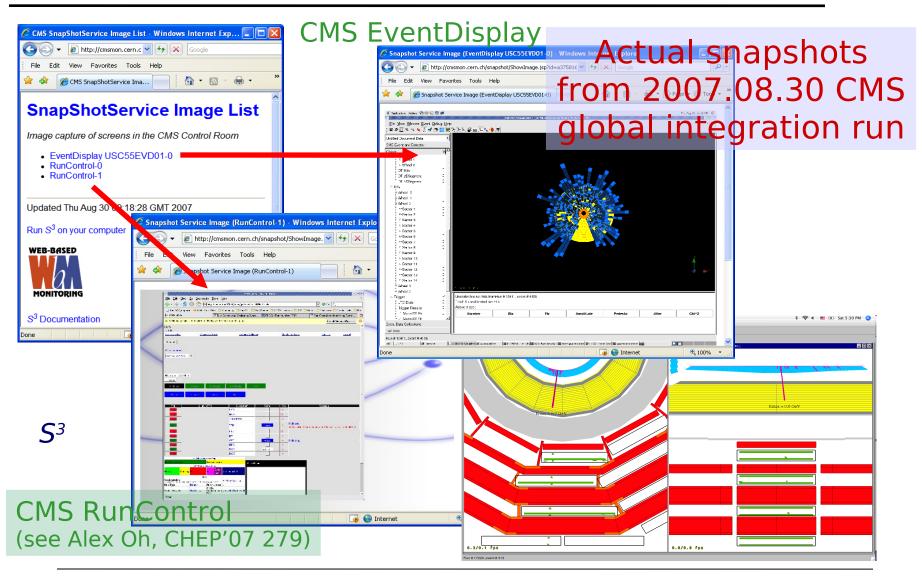
Screen Snapshot Service, *S³*

- **Remote Operations need Remote Knowledge**
  - ➤ **Operations screens, e.g. RunControl, HV Control, EventDisplay valuable for remote users to know what is going on**
  - ➤ **But normally have tight restrictions on access to nodes**

- **What is the Screen Snapshot Service?**
  - ➤ **A way to provide periodic, read-only copies of display images (snapshots) for remote viewing**
  - ➤ **Similar to products like VNC, pcAnywhere, and VGA2WEB but without the cost or danger of accidental remote control**
  - ➤ **Can be used to make private-network displays viewable on the public internet (useful for remote monitoring)**
  - ➤ **Uses commonly available technologies for portability and ease of use: Java, JSP, Tomcat**

Screen Snapshot Service Example

CMS EventDisplay

Actual snapshots from 2007.08.30 CMS global integration run

S^3

CMS RunControl
(see Alex Oh, CHEP'07 279)

summary

CMS is now in new phase:
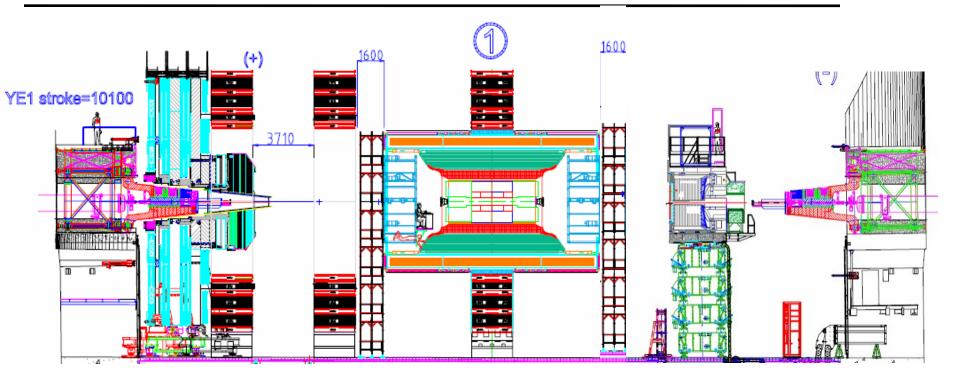
- **2/3 of detectors are in the collision hall. The rest of the heavy parts will be lowered by the end of this year. (pixel in March 2008).**

- **Commissioning "global runs", while each sub-detector work continues.**

- **Availability of huge amount of information (data, monitoring information…) is crucial for the CMS operation as well as the CMS remote operation. FNAL is taking the leading role in that area.**

- **No major problem: getting ready to see the collisions in mid 2008!**

---- Backup Slides ----

UXC: general logistic arrangement today

Completing phase 1 of +end programme on YB-1 and -2 Phase 2 starts later this week
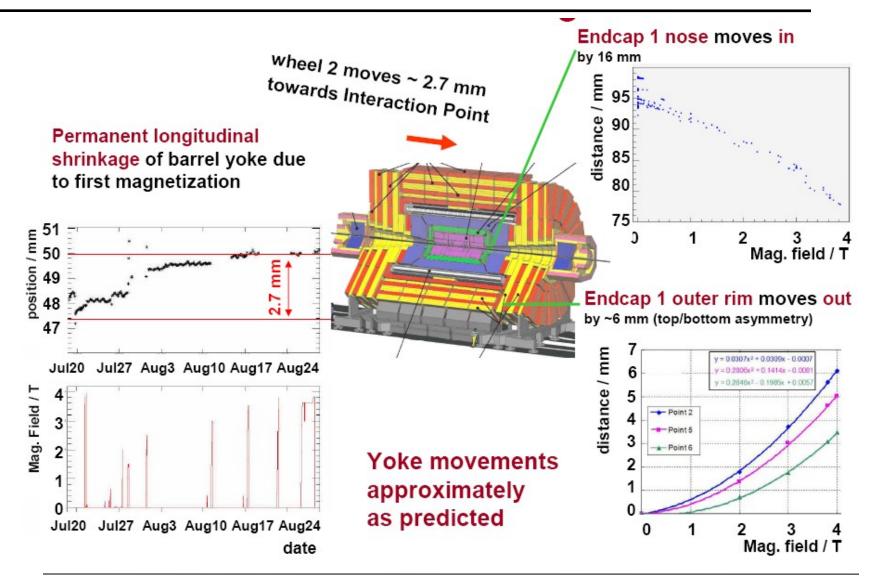
ECAL barrel installed

TK PP1, pipework and LV cabling off critical path. HB/EB cabling starting

Plug installed HF raising test CASTOR /TOTEM tests

Fwd pipe and VAX (pump) installed

Alignment and Magnetic Field

wheel 2 moves ~ 2.7 mm towards Interaction Point

Permanent longitudinal shrinkage of barrel yoke due to first magnetization

Endcap 1 nose moves **in** by 16 mm

Endcap 1 outer rim moves **out** by ~6 mm (top/bottom asymmetry)

Yoke movements approximately as predicted

$y = 0.0307x^2 + 0.0309x - 0.0007$
$y = 0.2806x^2 + 0.1414x - 0.0061$
$y = 0.2646x^2 - 0.1985x + 0.0057$

Point 2
Point 5
Point 6

Trigger and DAQ

- **Milestone: Global readout August 2007. These global runs include as many subdetectors as available, although only a small DAQ system, the "minidaq" system installed in USC is used. This system is a small subset of the full DAQ system, where the final hardware cabling and software can be tested, but only with a small subset of DAQ hardware and detector FEDs participating. These global runs also test the timing of the trigger.**

  - **The minidaq, global monitoring, event building and most of the subdetector software support were provided by the US CMS DAQ Team.**

- **the full RU-BU event builder computer farm is being installed and commissioned in the surface building at SX5.**

  - **This RU-BU fabric is planned to replace the minidaq for the September global run, which will then be the first test of a full size event builder. The installation and commissioning of these machines is a USCMS DAQ team project.**

View from above of the RU-BU machines and switch fabric installation at SX5

DAQ Sep07

- **Detector readout.**
  - 650 Slink/FMM cables   **100%**
  - 650 FRL/FMM modules   **100%**
  - 60 FRL/FMM crates   **100%**
  - 200 DAQ/DCS PCs   **100%**
  - IT infrastructures   **in Operation**

- **FED builders.**
  - Myrinet switches   **100%**
  - Myrinet Fibers (1024) **100%**
  - D2S optical cables   **100%**

- **SCX installation**
  - 110 water cooled racks   **100%**
  - 800 PC PE2950.   **100%**
  - EVB GBE switches   **100%**
  - GBE infrastructures   **100%**
  - DB and Mass storage **Installed**
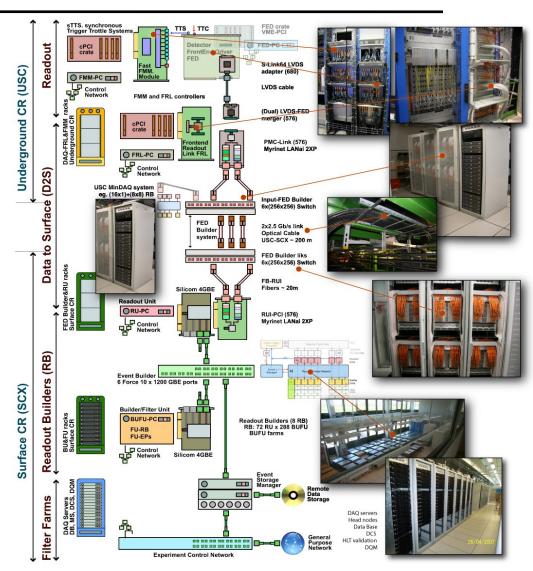
- **DAQ commissioning**
  - USC MiniDAQ (8x8)   **in Operation**
  - Monthly Global Run   **in Operation**
  - Software releases   **Ongoing**
  - D2S 2 x Tb/s Link   **100% tested**
  - SCX central DAQ   **Started**

Recent DAQ Activities

View from above of the RU-BU machines and switch fabric installation at SX5

USC during the Global Run at the End of May (GREM).The HF+ and the Global Trigger were successfully read out together through the full DAQ software chain using the "minidaq" system. The minidaq, global monitoring, event building and most of the subdetector software support were provided by US CMS DAQ Team.

UCSD students admire their installation work. A rack of RU-BU machines, powered up and racks of Myrinet switches

LHC@FNAL ROC Features

- **4 CERN-style consoles (8 workstations) shared by CMS & LHC scientists**
- **4 Projectors to share content within the ROC or to remote participants**
- **Videoconferencing installed for two consoles**
- **Webcams for remote viewing of ROC**
- **Secure keycard access to the ROC from Atrium and 1East Mtg Room**
- **Secure network for console PCs**
  - **Dedicated subnet, dedicated router w/Access Control Lists to restrict access.**
- **12-minute video essay displayed on the large "Public Display" used by docents from the Education Department to explain CMS and LHC to tour groups**
- **High Definition videoconferencing system for conference room**

- HD viewing of the ROC, and HD display capabilities in the ROC
- Secure group login capability for consoles, with persistent console sessions
  - Allows multiple users to share common console settings.
- Telephone lines share common number. International services enabled.
- Access to LHC Physics Center computing resources.

CMS ROC Shift Activities

The first group to use the ROC for shifts was the CMS Tier-1 computing administration operations team which was during weekday business hours.

- Responsible for FNAL Tier-1 resources (~ 50% of CMS computing in U.S.)
- Provides central support for the several university-based Tier-2 centers

The first detector group to use the ROC for shifts was the silicon tracker.

Current: CMS detector and trigger commissioning during the summer 2007.
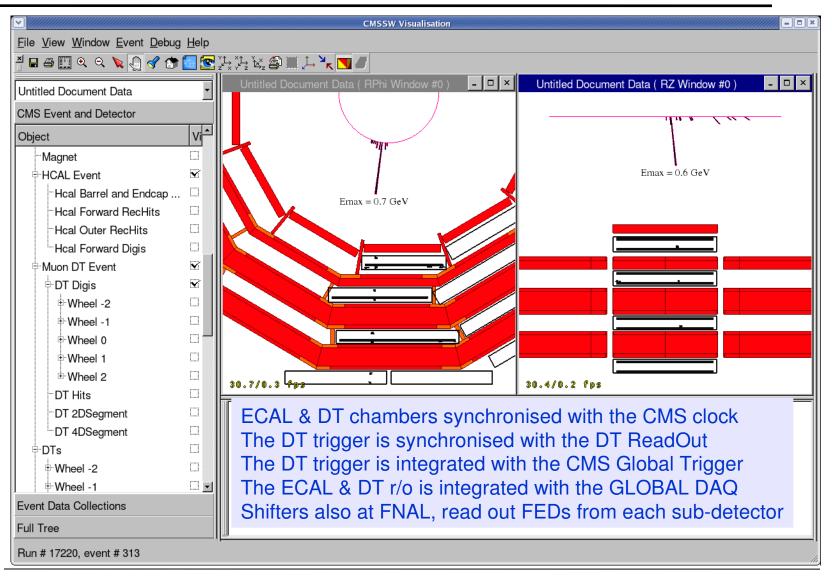
- Coordinated effort with the silicon tracker group & CMS ROC people working together.
- The remote shift operation at the ROC involved about 15 people from several different institutions from Feb – Jun 2007
- Remote Monitoring included
  - Data Quality
  - Data transfer & bookkeeping
  - Event display

ECAL & DT chambers synchronised with the CMS clock
The DT trigger is synchronised with the DT ReadOut
The DT trigger is integrated with the CMS Global Trigger
The ECAL & DT r/o is integrated with the GLOBAL DAQ
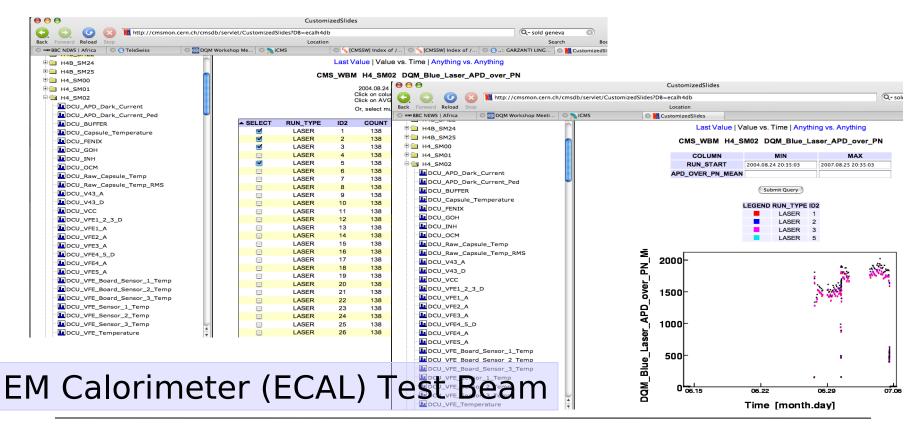Shifters also at FNAL, read out FEDs from each sub-detector

Trends over Time Plots

- **Search for performance anomalies**
- **Interactive, historical, downloadable**
- **Selection of type of data**
- **Zoom in on problems**

EM Calorimeter (ECAL) Test Beam

DQM / RootBrowser
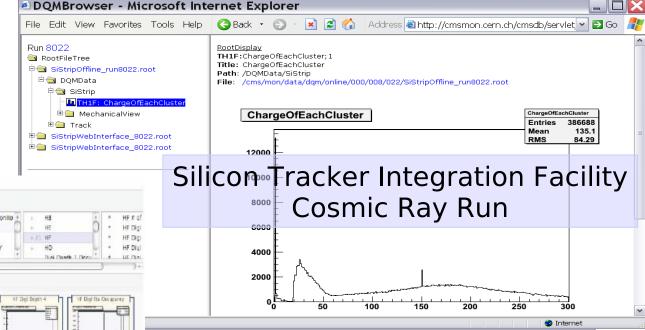
Dynamic
JavaScript
displays with
Tomcat/Java
backend

Silicon Tracker Integration Facility
Cosmic Ray Run
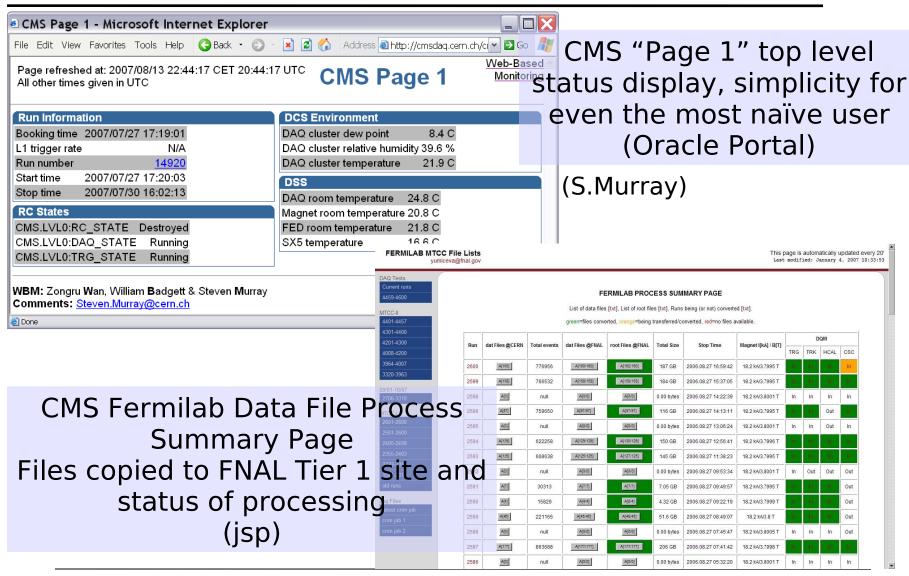
Hadron Calorimeter (HCAL)
Global Integration / Cosmic Ray
Run
New DQM GUI with user markup

(Lassi Tuura)

More Run Monitor Tools

CMS "Page 1" top level status display, simplicity for even the most naïve user (Oracle Portal)

(S.Murray)

CMS Fermilab Data File Process Summary Page
Files copied to FNAL Tier 1 site and status of processing
(jsp)
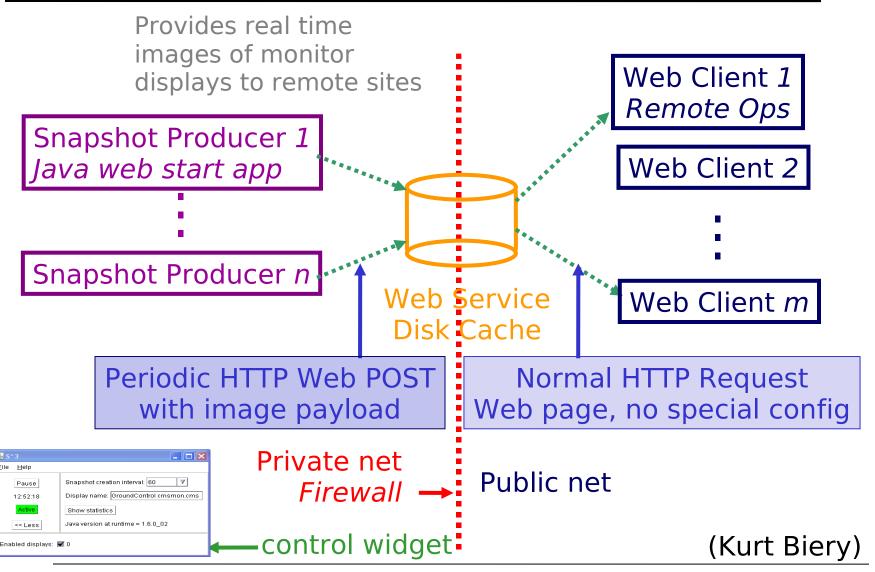
Screen Snapshot Service Mechanism

Provides real time images of monitor displays to remote sites

Snapshot Producer *1*
Java web start app

Snapshot Producer *n*

Web Service Disk Cache

Web Client *1*
Remote Ops

Web Client *2*

Web Client *m*

Periodic HTTP Web POST with image payload

Normal HTTP Request
Web page, no special config

Private net
Firewall →

Public net

control widget

(Kurt Biery)

ROC mini History and Plan

Location: Move to WH1 (LHC@FNAL)

Alan Stone arrives – full time ROC person

Tracker integ. test

HCAL Test Beam

2004	2005	2006	2007	2008 --

WBM effort continues.....

DQM preparation continues

Construction of WH11NW ROC room

Commissioning & DQM for physics runs ....

MTCC I and II